

Claims

We claim:

1. A solid oxide fuel cell assembly comprising:
first and second fuel cell layers each having an anode, a cathode and an electrolyte layer separating the anode and the cathode;
a separator plate having a defined thickness, a top face and a bottom face;
a first flow field element located between the top face of the separator plate and the first fuel cell layer, the first flow field element having a defined thickness and integrated means for delivering a reactant gas through the first flow field element and to the first fuel cell layer;
a second flow field element located between the bottom face of the separator plate and the second fuel cell layer, the second flow field element having a defined thickness and integrated means for delivering a reactant gas through the second flow field element and to the second fuel cell layer; and
means for conducting an electrical current from the first fuel cell layer through the first flow field element, the separator plate and the second flow field element, the means for conducting being integrated into a portion of the thickness of each of: the separator plate, the first flow field element and the second flow field element.
2. An assembly according to claim 1, wherein the first flow field element comprises a plurality of flat members; wherein each member has a plurality of apertures; and wherein the members are arranged in a stack so that the apertures form a flow path for the reactant gas.
3. An assembly according to claim 2, wherein the flat members are formed from a ceramic material.
4. An assembly according to claim 3, wherein the ceramic material includes at least one composition selected from the group consisting of: yttria stabilized zirconia, alumina, magnesium alumina spinel, titania, ceria and mixtures thereof.

5. An assembly according to claim 4, wherein the means for conducting an electrical current comprises a connected pattern of conductive vias situated through each of: the separator plate, each flat member of the first flow field element and the second flow field element.

6. An assembly according to claim 5, wherein at least a portion of the conductive vias include at least one composition selected from the group consisting of: noble metals, alloys of noble metals, nickel, chromium, alloys of chromium, conducting oxide ceramics and ceramic-metal composites.

7. An assembly according to claim 6, wherein the means for conducting an electrical current further comprises a conductive coating applied to at least a portion each of the following: an outer surface of each flat member of the first flow field element, the top face of the separator, the bottom face of the separator and an outer surface of the second flow field element; and wherein the conductive coating is electrically connected to at least a portion of the conductive vias.

8. An assembly according to claim 7, wherein the conductive coating includes any composition selected from the group consisting of: noble metals, alloys of noble metals, nickel, chromium, alloys of chromium, conducting oxide ceramics and ceramic-metal composites.

9. An assembly according to claim 4, further comprising a conductive coating applied to at least a portion each of the following: an outer surface of each flat member of the first flow field element, the top face of the separator, the bottom face of the separator and an outer surface of the second flow field element.

10. An assembly according to claim 9, the conductive coating includes at least one composition selected from the group consisting of: noble metals, alloys of noble metals,

nickel, chromium, alloys of chromium, conducting oxide ceramics and ceramic-metal composites.

11. An assembly according to claim 1, further comprising a conductive coating applied to at least a portion each of the following: an outer surface of each flat member of the first flow field element, the top face of the separator, the bottom face of the separator and an outer surface of the second flow field element.

12. An assembly according to claim 11, the conductive coating includes at least one composition selected from the group consisting of: noble metals, alloys of noble metals, nickel, chromium, alloys of chromium, conducting oxide ceramics and ceramic-metal composites.

13. An assembly according to claim 1, wherein the means for conducting an electrical current comprises a connected pattern of conductive vias situated through each of: the separator plate, each flat member of the first flow field element and the second flow field element.

14. An assembly according to claim 13, wherein at least a portion of the conductive vias includes at least one composition selected from the group consisting of: noble metals, alloys of noble metals, nickel, chromium, alloys of chromium, conducting oxide ceramics and ceramic-metal composites.

15. An assembly according to claim 14, wherein the means for conducting an electrical current further comprises a conductive coating applied to at least a portion each of the following: an outer surface of each flat member of the first flow field element, the top face of the separator, the bottom face of the separator and an outer surface of the second flow field element; and wherein the conductive coating is electrically connected to at least a portion of the conductive vias.

16. An assembly according to claim 15, wherein the conductive coating includes any composition selected from the group consisting of: noble metals, alloys of noble metals, nickel, chromium, alloys of chromium, conducting oxide ceramics and ceramic-metal composites.

17. An assembly according to claim 8, wherein the separator plate is formed from a dense ceramic material.

18. An assembly according to claim 17, wherein the dense ceramic material includes at least one composition selected from the group consisting of: yttria stabilized zirconia, alumina, magnesium alumina spinel and mixtures thereof.

19. An assembly according to claim 18, wherein the apertures are elongated slots arranged in a series of rows and wherein the flowpath is a series of individual, undulating channels.

20. An assembly according to claim 19, further comprising restrictive orifices for regulating the flow of reactant gas into the individual, undulating channels.

21. An assembly according to claim 20, further comprising an integrated distribution plenum located proximate to an outer edge of the first flow field element and in fluidic contact with the orifices.

22. An assembly according to claim 18, wherein the apertures arranged in an overlapping pattern of holes having a diameter selected to optimize flow properties of the reactant gas passing through the apertures.

23. An assembly according to claim 18, further comprising sealing means for containing gases within an area surrounding the separator plate, the flat members of the first

the first flow field element, the second flow field element and the first and second fuel cell layers.

24. An assembly according to claim 23, wherein the sealing means consists of at least one of: a sealant material and means for applying a compressive force.

25. An assembly according to claim 10, wherein the separator plate is formed from a dense ceramic material.

26. An assembly according to claim 25, wherein the dense ceramic material includes at least one composition selected from the group consisting of: yttria stabilized zirconia, alumina, magnesium alumina spinel and mixtures thereof.

27. An assembly according to claim 2, wherein the apertures are elongated slots arranged in a series of rows and wherein the flowpath is a series of individual, undulating channels.

28. An assembly according to claim 27, further comprising restrictive orifices for regulating the flow of reactant gas into the individual, undulating channels.

29. An assembly according to claim 28, further comprising an integrated distribution plenum located proximate to an outer edge of the first flow field element and in fluidic contact with the orifices.

30. An assembly according to claim 2, wherein the apertures arranged in an overlapping pattern of holes having a diameter selected to optimize flow properties of the reactant gas passing through the apertures.

31. An assembly according to claim 1, wherein the separator plate is formed from a dense ceramic material.

32. An assembly according to claim 31, wherein the dense ceramic material includes at least one composition selected from the group consisting of: yttria stabilized zirconia, alumina, magnesium alumina spinel and mixtures thereof.

33. A layered fuel cell interconnect apparatus, the apparatus comprising:
a first set of flat plates, each plate having a pattern of apertures and a first means for conducting an electrical current through the first set of plates, the first set of the plates being arranged in a stack so that the apertures of each plate form a flowpath for a first reactant gas;

a second set of flat plates, each plate having a pattern of apertures and a second means for conducting an electrical current through the second set of plates, the second set of plates being arranged in a stack so that the apertures of each plate form a flowpath for a second reactant gas;

at least one separator plate having a series of filled vias electrically connected to the first means for conducting an electrical current on one side of the separator plate and to the second means for conducting an electrical current on an opposite of the separator plate, the separator plate being positioned between the first set of plates and the second set of plates so as to segregate the first reactant gas from the second reactant gas.

34. An assembly according to claim 33, wherein the first set of plates and the second set of plates are both formed from a ceramic material.

35. An assembly according to claim 34, wherein the ceramic material includes at least one composition selected from the group consisting of: yttria stabilized zirconia, alumina, magnesium alumina spinel, titania and ceria.

36. An assembly according to claim 33, wherein the first means for conducting an electrical current comprises a connected pattern of conductive vias, the conductive vias being electrically connected to the filled vias of the separator plate.

37. An assembly according to claim 36, wherein the second means for conducting an electrical current comprises a connected pattern of conductive vias, the conductive vias being electrically connected to the filled vias of the separator plate.

38. An assembly according to claim 33, wherein the first reactant gas comprises a fuel gas for a fuel cell and wherein the first means for conducting an electrical current is formed from at least one composition selected from the group consisting of: silver; palladium; gold; platinum; alloys of silver; alloys of palladium; alloys of gold; alloys of platinum; nickel; chromium; high-chromium alloys; and cermets formed by combining at least one of the following metals: nickel, chromium and high chromium alloys, with at least one of the following ceramic materials: alumina, magnesium aluminum spinel, ceria, YSZ, titania, doped-titania and other such n-type oxide conductors; and any mixture thereof.

39. An assembly according to claim 38, wherein the second reactant gas comprises an oxidant gas for a fuel cell and wherein the second means for conducting an electrical current is formed from at least one composition selected from the group consisting of: silver; palladium; gold; platinum; alloys of silver; alloys of palladium; alloys of gold; alloys of platinum; cermets prepared by combining a metals with at least one of the following ceramic materials: alumina, magnesium alumina spinel and YSZ; p-type conducting oxide ceramics; Sn-doped indium oxide; Pr-doped indium oxide; indium oxide; zirconium oxide; praseodymium oxide; tin oxide; titanium oxide; doped rare earth manganites, doped rare earth cobaltites; doped rare earth ferrites; and any mixture thereof.

40. An assembly according to claim 33, wherein the first reactant gas comprises an oxidant gas for a fuel cell and wherein the first means for conducting an electrical current is formed from at least one composition selected from the group consisting of: silver; palladium; gold; platinum; alloys of silver; alloys of palladium; alloys of gold; alloys of platinum; cermets prepared by combining a metals with at least one of the following ceramic materials: alumina, magnesium alumina spinel and YSZ; p-type conducting oxide ceramics;

Sn-doped indium oxide; Pr-doped indium oxide; indium oxide; zirconium oxide; praseodymium oxide; tin oxide; titanium oxide; doped rare earth manganites, doped rare earth cobaltites; doped rare earth ferrites; and any mixture thereof.

41. An assembly according to claim 36, wherein the first reactant gas comprises a fuel gas for a fuel cell and wherein the first means for conducting an electrical current is formed from at least one composition selected from the group consisting of: silver; palladium; gold; platinum; alloys of silver; alloys of palladium; alloys of gold; alloys of platinum; nickel; chromium; high-chromium alloys; and cermets formed by combining at least one of the following metals: nickel, chromium and high chromium alloys, with at least one of the following ceramic materials: alumina, magnesium aluminum spinel, ceria, YSZ, titania, doped-titania and other such n-type oxide conductors; and any mixture thereof.

42. An assembly according to claim 36, wherein the first reactant gas comprises an oxidant gas for a fuel cell and wherein the first means for conducting an electrical current is formed from at least one composition selected from the group consisting of: silver; palladium; gold; platinum; alloys of silver; alloys of palladium; alloys of gold; alloys of platinum; cermets prepared by combining a metals with at least one of the following ceramic materials: alumina, magnesium alumina spinel and YSZ; p-type conducting oxide ceramics; Sn-doped indium oxide; Pr-doped indium oxide; indium oxide; zirconium oxide; praseodymium oxide; tin oxide; titanium oxide; doped rare earth manganites, doped rare earth cobaltites; doped rare earth ferrites; and any mixture thereof.

43. An assembly according to claim 33, wherein the separator plate comprises at least one layer of a dense ceramic material.

44. An assembly according to claim 43, wherein the dense ceramic material includes at least one composition selected from the group consisting of: yttria stabilized zirconia, alumina, magnesium alumina spinel and any mixture thereof.

45. An assembly according to claim 33, wherein the apertures for at least one of: the first set of plates and the second set of plates, have at least one of the shapes selected from the group consisting of: circles, ovals, triangles, rectangles, pentagons, hexagons and higher order polygons.

46. An assembly according to claim 45, wherein the shape of the apertures of a specific plate have varying dimensions relative to other apertures on the specific plate.

47. An assembly according to claim 45, wherein the shape of the apertures are selected to favorably influence pressure drop of the first and second reactant gases within each respective set of plates.

48. An assembly according to claim 33, wherein the pattern of apertures for at least one of: the first set of plates and the second set of plates, are arranged to form individual channels running along a length of each plate.

49. An assembly according to claim 48, wherein the individual channels possess an inlet with a defined size and further comprising orifice means for regulating entry of reactant gas flow into the individual channel are fluidically connected to each channel inlet, wherein each orifice means is smaller than the channel inlet to which each orifice means is connected.

50. An assembly according to claim 49, further comprising a distribution plenum fluidically connected to every orifice means, the distribution plenum being position in an upstream position relative to the individual channels.

51. A method for constructing an interconnect apparatus for use in a fuel cell stack, the method comprising:

providing a plurality of flat members capable of forming separate reactant gas flow field;

providing an impermeable separator plate;
forming a pattern of apertures on each flat member;
providing a material capable of conducting an electrical current to the separator plate and to at least a portion of the flat members;
stacking the flat members on both sides of the separator plate so as to surround the separator plate;
aligning the flat members on each side of the separator plate so as to insure a viable electrical connection exists throughout the flat members and the separator plate and so as to insure the pattern of apertures in the stacked members forms a flow field for reactant gases on each side of the separator plate; and
sealing the stacked and aligned flat members and separator plate to insure that reactant gases are contained within the flow field on each side of the separator plate.

52. A method according to claim 51, wherein the flat members are formed from a ceramic material.

53. A method according to claim 52, wherein the ceramic material is at least one composition selected from the group consisting of: yttria stabilized zirconia, alumina, magnesium alumina spinel, titania, ceria and mixtures thereof.

54. A method according to claim 51, wherein the separator plate is formed from a dense ceramic material.

55. A method according to claim 54, wherein the ceramic material is at least one composition selected from the group consisting of: yttria stabilized zirconia, alumina, magnesium alumina spinel and mixtures thereof.

56. A method according to claim 52, wherein the flat members are formed by a tape-casting process.

57. A method according to claim 54, wherein the separator plate is formed by a tape casting process.

58. A method according to claim 51, wherein the providing a material capable of conducting an electrical current further comprises: forming apertures in the separator plate and placing a dense conductive material in the apertures of the separator plate.

59. A method according to claim 58, wherein the providing a material capable of conducting an electrical current further comprises: forming apertures in each flat member and placing a conductive material in the apertures of each flat member.

60. A method according to claim 59, wherein the dense material for the separator plate is at least one composition selected from the group consisting of: noble metals, alloys of noble metals, nickel, chromium, alloys of chromium, conducting oxide ceramics and ceramic-metal composites; and wherein the conductive material for each flat member is at least one composition selected from the group consisting of: noble metals, alloys of noble metals, nickel, chromium, alloys of chromium, conducting oxide ceramics and ceramic-metal composites.

61. A method according to claim 51, wherein the providing a material capable of conducting an electrical current further comprises: forming apertures in each flat member and placing a conductive material in the apertures of each flat member.

62. A method according to claim 61, wherein the conductive material for each flat member is at least one composition selected from the group consisting of: noble metals, alloys of noble metals, nickel, chromium, alloys of chromium, conducting oxide ceramics and ceramic-metal composites.

63. A method according to claim 51, wherein the providing a material capable of conducting an electrical current further comprises: forming apertures in the separator plate,

placing a dense conductive material in the apertures of the separator plate, and depositing a continuous layer of a conductive material on at least a portion of exposed surfaces of the flow field on at least one side of the separator plate.

64. A method according to claim 63, wherein the dense material for the separator plate is at least one composition selected from the group consisting of: noble metals, alloys of noble metals, nickel, chromium, alloys of chromium, conducting oxide ceramics and ceramic-metal composites; and wherein the conductive material for each flat member is at least one composition selected from the group consisting of: noble metals, alloys of noble metals, nickel, chromium, alloys of chromium, conducting oxide ceramics and ceramic-metal composites.

65. A method according to claim 51, wherein forming the apertures further comprises: forming a pattern of apertures on each flat member in at least one shape selected from the group consisting of: circles, ovals, triangles, rectangles, pentagons, hexagons and higher order polygons.

66. A method according to claim 65, wherein the shape of the apertures of a specific flat member have varying dimensions relative to other apertures on the specific flat member.

67. A method according to claim 65, wherein the shape of the apertures are selected to favorably influence pressure drop of reactant gases within each flow field.

68. A method according to claim 51, wherein the sealing the stacked and aligned flat members and separator plate further comprises: applying an adhesive sealant material to all outer edges of the flat members and to all outer edges of the separator plate.

69. A method according to claim 51, wherein the sealing the stacked and aligned flat members and separator plate further comprises: applying a compressive force to the stacked and aligned flat members and separator plate.

70. A method according to claim 51, wherein the aligning the flat members further comprises: insuring that the flow field on each side of the separator plate includes an inlet fluidically connected to each flow field along one edge of the stacked and aligned flat members and separator plate and an outlet fluidically connected to each flow field along a separate edge of the stacked and aligned flat members and separator plate; and wherein the sealing the stacked and aligned flat members and separator plate further comprises: insuring that reactant gases enter the stacked and aligned flat members and separator plate only through the inlets and that reactant gases exit only through the outlets.

71. A method according to claim 70, further comprising: prior to sealing the stacked and aligned flat members and separator plate, forming at least one restrictive orifice at a position upstream relative to the inlets.

72. A method according to claim 71, further comprising: prior to sealing the stacked and aligned flat members and separator plate, forming a distribution plenum fluidically connected to the restrictive orifice.

73. A method according to claim 52, wherein the separator plate is formed from a dense ceramic material.

74. A method according to claim 73, wherein the flat members are formed by a tape-casting process.

75. A method according to claim 74, wherein the providing a material capable of conducting an electrical current further comprises: forming apertures in the separator plate and placing a dense conductive material in the apertures of the separator plate.

76. A method according to claim 75, wherein the providing a material capable of conducting an electrical current further comprises: forming apertures in each flat member and placing a conductive material in the apertures of each flat member.

77. A method according to claim 76, wherein forming the apertures further comprises: forming a pattern of apertures on each flat member in at least one shape selected from the group consisting of: circles, ovals, triangles, rectangles, pentagons, hexagons and higher order polygons.

78. A method according to claim 77, wherein the shape of the apertures of a specific flat member have varying dimensions relative to other apertures on the specific flat member.

79. A method according to claim 78, wherein the shape of the apertures are selected to favorably influence pressure drop of reactant gases within each flow field.

80. A method according to claim 79, wherein the ceramic material is at least one composition selected from the group consisting of: yttria stabilized zirconia, alumina, magnesium alumina spinel, titania, ceria and mixtures thereof.

81. A method according to claim 80, wherein the dense ceramic material is at least one composition selected from the group consisting of: yttria stabilized zirconia, alumina, magnesium alumina spinel and mixtures thereof.

82. A method according to claim 81, wherein the dense material for the separator plate is at least one composition selected from the group consisting of: noble metals, alloys of noble metals, nickel, chromium, alloys of chromium, conducting oxide ceramics and ceramic-metal composites; and wherein the conductive material for each flat member is at least one composition selected from the group consisting of: noble metals, alloys of noble

metals, nickel, chromium, alloys of chromium, conducting oxide ceramics and ceramic-metal composites.

83. A method according to claim 82, wherein the aligning the flat members further comprises: insuring that the flow field on each side of the separator plate includes an inlet fluidically connected to each flow field along one edge of the stacked and aligned flat members and separator plate and an outlet fluidically connected to each flow field along a separate edge of the stacked and aligned flat members and separator plate; and wherein the sealing the stacked and aligned flat members and separator plate further comprises: insuring that reactant gases enter the stacked and aligned flat members and separator plate only through the inlets and that reactant gases exit only through the outlets.

84. A method according to claim 83, further comprising: prior to sealing the stacked and aligned flat members and separator plate, forming at least one restrictive orifice at a position upstream relative to the inlets.

85. A method according to claim 84, further comprising: prior to sealing the stacked and aligned flat members and separator plate, forming a distribution plenum fluidically connected to the restrictive orifice.

86. An assembly according to claim 4, wherein the separator plate is formed from a dense ceramic material.

87. An assembly according to claim 86, wherein the dense ceramic material includes at least one composition selected from the group consisting of: yttria stabilized zirconia, alumina, magnesium alumina spinel and mixtures thereof.